EXECUTIVE SUMMARY

The aim of this report is to explain the limitations inherent in communications across a communicational telephone link, and also to explore the concept of layering for the internet and TCP/IP protocols.

The objective of this report is to browse the problems that hamper data transmission over a Public Switch Telephone Network (PSTN) and to see how these dilemmas are defeated. Also, this report explains the layers involved in internet communication, specifically the TCP/IP.

This report begins with an introduction to the need for communications. Subsequently, the report demonstrates the telephone and at the outset, the use of it, and how it has changed progressively to follow the demands of modern communication.

The end of the report explains the need for the layer model, especially the TCP/IP and how it was generated from a previous network model, the OSI layers scheme.

This report shows the rapid changes and the dilemmas that are facing present day communications. The information that is used for the report subject headings was all derived from different resources, such as books, websites, and journal articles.

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1.0: Introduction

For a long time humans have tried to generate ideas for the communication and transmission of information all around the world. The invention of the telephone was one of the ideas that was used to send the human voice. The transmission of the voice is simply an exchange of information between two users. Moreover, this invention has crystallized many ideas and methods for researchers, especially since the inception of the digital age and the internet. The Public Switch Telephone Network (PSTN) became the path not only for transmitting the voice, but also, for transmitting data from one computer to another.

This report is going to explore the primitive use of the telephone and how it was developed gradually through the years. This exploration is going to start with explaining the limitations of the telephone and go on to explain how it has changed to meet recent communication demands.

This report also browses the concept of layered communications and the set of protocols that have been invented to aid the developers to a better understanding of the internet. This will take place after a brief history of the internet.

2.0: The Public Switch Telephone (PSTN)

The Public Switch Telephone Network (PSTN) was designed about 120 years ago by Alexander G. Bell, to convey the human voice in intelligible form and also to facilitate and to arrange the telephone service by switching operations of the telephone network for numerous customers, whether for local or long-distance calls.

However, nowadays the telephone is systemized in an hierarchical model, meaning that each telephone subscriber is connected with the local central office by two copper wires and this function is known as the local loop. Furthermore, each central office contains a number of outgoing lines (toll connecting trunks) directed to switching centres or toll offices, the communication in this system being via high bandwidth (inter-toll trunks), (See Figure 1 for a medium-distance call example) [1].

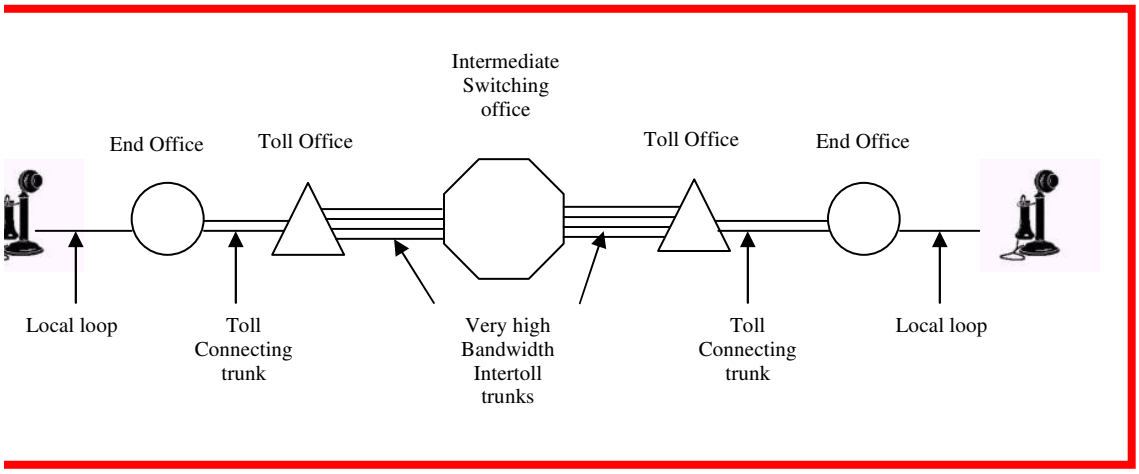

Figure 1. Medium Distance Call

The idea that was used in the past to transmit the voice via PSTN was basically an analog signal through the telephone system. This system contains a lot of disadvantages, such as the loss of information. The cost of this system was very high, and the maintenance very complicated.

Moreover, the digital age started during the 1960's and as a result the way of transmitting the signal was changed from analog to digital signalling, which contains a number of advantageous features [1]: (See Figure 2. Analog signal and digital signal)[2].

- It is easy to calculate how far the signal can propagate.
- The signal can be restored to its original value.
- It is very hard to lose information during the process of transmission.

- All complex multimedia can be diffused to make an efficient use of the circuits and equipment.
- The cost of the use of a digital signal is much cheaper and the maintenance much easier than with the old system.

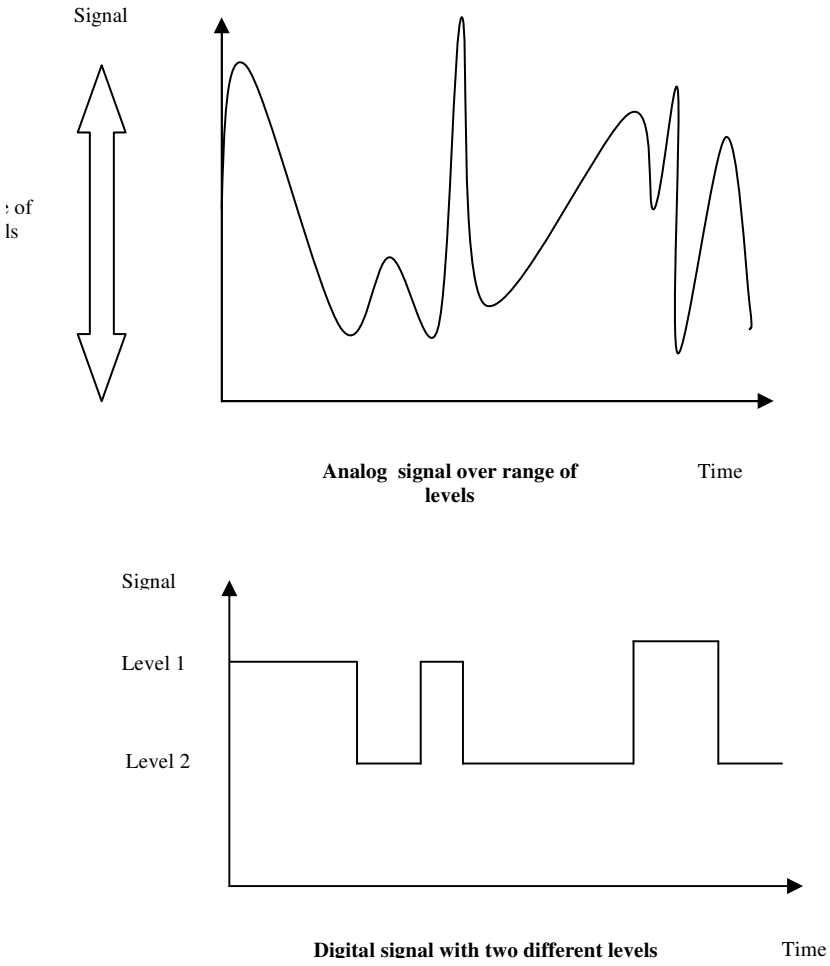

Figure 2. Analog Signal and Digital Signal

2.1: Transmission Media:

The are two ways for transmission media to carry the signal between user computers. They are either by physical means (wiring), such as a twisted pair, coaxial cable, and optical fibre, or by non physical means (wireless), such as Microwave, Satellite, Radio, Cell phone and GSM.

Furthermore, there are several problems occurring during the signal transmission and the problems are as follows:

- Attenuation: This problem occurs mostly in the media for electricity (wiring). The further the signal travels the weaker it gets, which cause a loss of energy depending on the frequency. If the attenuation is very high, the receiver may not be able to discover the signal. Amplifiers are used to remedy the frequency, but they cannot restore the signal back to its original shape.
- Delay distortion: If the signal travels for a long distance, some of the component signals can be delayed, which interferes with the new signal, hence, causing an incorrect reception.
- Noise: There are several types of noise, which effect the transmission media; some noises can be decreased by "good design and preventive calculations"[3]. Some of this noise is related to the PSTN use as follows:
    A. Crosstalk: This noise can occur in both physical or wireless transmissions. This noise is the other conversation in the background that appears when two subscribers are using the phone. It can be reduced by separating the cables or by shielding the media.
    B. Thermal Noise: the cause of this noise is the interaction between electronic components, which affects the frequency of the transmission. The reason for this noise is associated with copper or other metallic conductors.
    C. Radiation Noise: this is caused by any phenomena in the atmosphere, such as rain, snow, fog, etc. This noise occurs in the wireless transmission and especially with Radio waves transmission, whether terrestrial (phone- coaxial cable) or non terrestrial (wireless)[4].
    D. Impulse Noise: The cause of this noise is from electrical spikes, which interfere with communication for short periods. This noise is reduced by filtering the communication.
- Bandwidth: The bandwidth is the limit of the frequency that any electrical channel can process. If there is not sufficient bandwidth, some of the frequency will be lost and the signal will be distorted.
- Local loop: Due to the high cost of converting the local loops to the transmission of digital signals, local loops transmitted only the analog signal for a long time.

2.2: Surmounting Transmission Media Problems:

The problems above, along with the need for speed, aided the improvement of the technology. However, it was at the insistence of the technology developers, that the means and devices to overcome these dilemmas were made available. To facilitate data transmission through dial-up lines, some of the devices developed were as follows:

A. Modems: The modem is a device that aids the computers to "check hands", meaning that a modem is a device that transmits the digital signal from one computer to another via PSTN. Furthermore, the process of transmitting via the modem by converting the digital data to analog signals, back and forth to suit, and to transmit the signal over the local loop and the trunks in the PSTN system and back again to a digital signal, from another modem to receive

the data, is known as “Modulator and Demodulator”. Moreover, the modem is inserted between computers not only for converting the signals but also to gain a rapid transmission of the data. Despite of the variety of modems, modems still suffer from different problems such as echo suppression and problems with incoming calls. (See Figure 3. Conversion of the modems to the signals)[5].

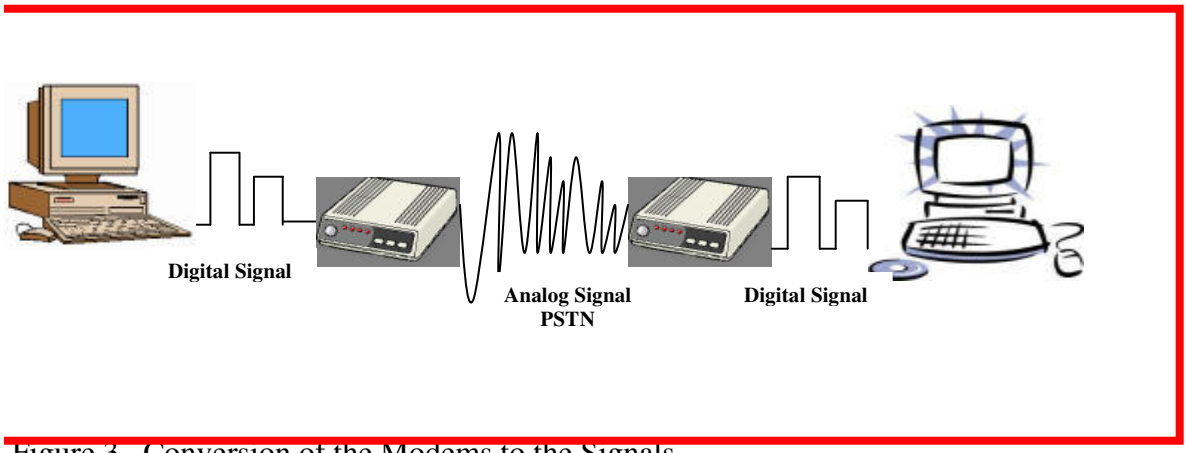

Figure 3. Conversion of the Modems to the Signals

B. ISDN: During the 1980's the developers started to build new telephone systems working over the existing phone lines and forcing it to support complex multimedia for home and workplace, by converting the telephone switching system to digital circuits. This new system is called the Integrated Service Digital Network (ISDN). Moreover, there are two services of ISDN, Basic Rate Interface (BRI) and Primary Rate Interface (PRI), but the most popular one is the first one. Furthermore, "(BRI) connection through three channels, two "B"(bearer) channels at 64 Kbps to send the data and one "D"(delta) channel at 16 Kbps[6], are used to connect and disconnect the B channels. "The speed (ISDN) is 10 time faster than the 28.8 Kbps modem"[7]. Despite this service solving the majority of the problems mentioned before, which are the noise and the speed during transmitting the data, this system still contains a lot of disadvantages. The main two disadvantages are:

- Sometime this service is not available in all areas ("distance limitation between subscriber and service centre about 18,000ft")[8].
- The cost of ISDN, whether for the service or for buying the ISDN adapter, is more expensive than the analog service and modem. Also upgrading central office from switch to ISDN represents a cost of about "$500,000" for each local loop [6].

C. ADSL: Asymmetric digital Subscriber Line, is one of the recent communication technologies and was proposed during the beginning of the 1990's. The idea of ADSL is to split the subscriber's existing PSTN phone line into two sections by inserting a modem and a micro-filter into the telephone socket. The micro-filter is designed to split the frequencies and to save them from any conflict, one section for the voice and the other to transmit data at a speed of 576.0K bps. Moreover, splitting the line gives the user the opportunity to surf the web while making a phone call. Furthermore, with this high speed the user who has this service has the opportunity to surf the internet and access or download all recent complex media such as:

playing online games, using a web cam, video, audio, etc. Furthermore, ADSL contains disadvantages the main two are:

- Non nationwide coverage.
- Download speed not guaranteed.

As a result, despite the developers inventing all the solutions above and others such as FTTC, HFC, VDSL, HDSL, etc. and trying to develop to reach the recent communications demands, the main problem that always faces them is how to upgrade the PSTN to transmit all types of data in a very rapid way and without spending a large amount of money, whether for the service or for upgrading.

3.0: The Layered Models:

The first network scheme, which appeared with an idea of a series of layers before the invention of the internet[10], was developed by the International Standards Organization (ISO). They decided to create a network model that contains specific description techniques for hardware and software to aid the networking vendors or developers to achieve a better understanding of the networks through the interaction between hardware and software to solve a communication problem. Moreover, the use of this model symbolized the myriad of networking processes and described them in different layers. Furthermore, the idea behind these layers is to transfer the networking process to simple components, which will act as a framework or as a guide to help the developers to focus on specific areas. The ISO developed the Open System Interconnection (OSI). Although, other networking models have been created for networking or the internet, OSI is like an architectural reference for all new models presented.

The OSI model is a conceptual model, which contains seven layers, each layer describing particular network functions. Also, each layer is implemented independently and with out affecting the service provided to other layers. (See Figure 4. OSI 7 Layers [10].

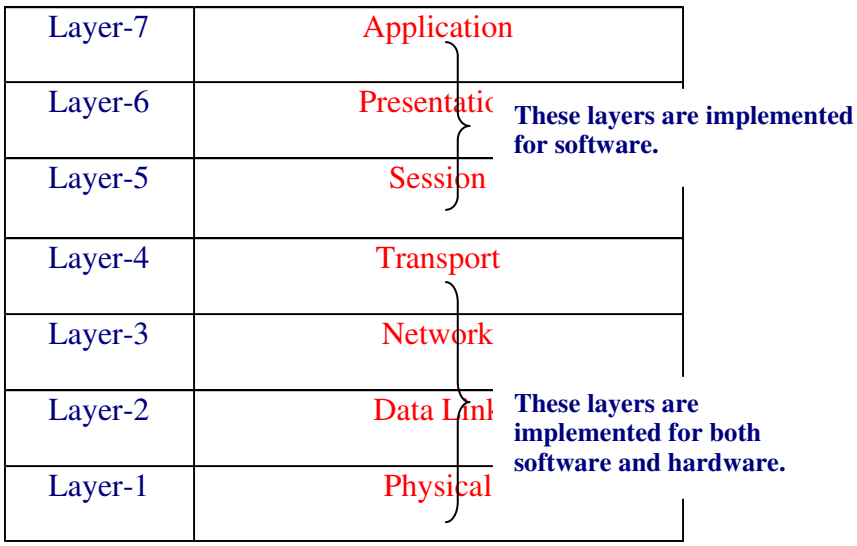

Figure 4. OSI 7 Layers

3.1: The TCP/IP:

During the 1950's the United States Advanced Research Project Agency (ARPS) with the Department of Defence (DOD) were working together to find a communication scheme that would allow the U.S. control over its military, even after a major attack such as a nuclear attack. After hard work and developing plenty of ideas the (ARPS) presented at the beginning of the 1970's the Transmission Control Protocol/Internet Protocol (TCP/IP). The fundamental goal of this protocol was to enable computers in different locations to communicate with each other.

TCP: This re-engineered the messages to fit the network packets, making suitable forms for the packets and returning them to the original message at the destination of the transmission, also securing the messages from any errors that might occur in the network process.

IP: IP "… is responsible for routing packets through the interconnect networks"[10].

3.2: The TCP/IP Layer Model:

The TCP/IP module is a set of protocols. This module was the first module that was developed and was widely used after the generation of the internet invention. The idea of this model was deduced from the OSI reference module, yet the researcher created a new layering module that would be adequate for the internet process. (See Figure 5. The TCP/IP layering model)[9].

Layer-5	Application
Layer-4	Transport
Layer-3	Internet
Layer-2	Network Interface
Layer-1	Physical

Figure 5. The TCP/IP Layering Model

The purpose of each layer is as follows:

(The layers 1-2 4-5 are similar to the layers in the OSI module).

Layer-1: Physical

This layer corresponds to the network hardware.

Layer-2: Network Interface

The protocols of this layer are to re-engineer the formation of the data into frames and transmit these frames from a computer through the network. If the transmission of the frame is complete, it will be passed to the next layer, but if not, it will be discarded.

Layer-3: Internet

The internet layer protocols specify three fundamental processes, which are addressing, packaging, and routing while the message is sent across the internet.

Layer-4: Transport

The protocols of Layer-4 are to secure the transmission process by ensuring that the host is receiving the data, in addition, securing it by special mechanism from TCP/IP scheme such ARP, ICMP, and IGMP.

Layer-5: Application

There are two categories for network applications [10]:

- Winsock: this application uses the Windows sockets service, which contains an advantage over the use of the internet such as Telnet, IRC, FTP, etc.
- NetBIOS: uses messaging service over the TCP/IP layers. Windows NT 4.0 still uses this application.

The protocols of this layer is to indicate the use of the internet by one application.

3.3: Internet Protocol (IP) Addresses Scheme:

The IP Address is a binary number that contains 32-bits (Ones and Zeros). The IP Address is an identifier number for each computer in the internet. It identifies the connection between a computer and a network. The need for this number or software for the transmission of the data when it goes across the net is because it goes from one IP Address to another.

Furthermore, there are five classes for the IP Address. The classes are A, B, C, D, and E. The first four bits of each class is the network ID. The rest of the address is a host ID. Furthermore, the number of the network ID increases between the groups of the IP Addresses gradually, which makes the difference in

the classes. (See Figure 6. IP Classes.)

Class	Divided to
A	N.H.H.H
B	N.N.H.H
C	N.N.N.H

Figure 6. IP Classes

Class D is used for developmental experiments, and also for "Multicasting, which allows the delivery to a set of computers"[9].

The dilemma that the researchers have discovered in the past ten years, is that the number of IP Addresses is running out, and the cause of that is due to the emergence of recent technology and of the new of communications methods which have appeared, such as surfing the web with cell phones and other new methods. This new method of communication draws on a myriad of IP Addresses. In addition, the wasteful use of addresses by internet users also adds to the aggravation of this dilemma. Furthermore, the developers invented a new addressing scheme as a substitute to the previous one, which was the IPv4, and they developed it into the IPv6. The idea behind the new scheme is to increase the size of the IP Address from 32-128 bits, which gives it the opportunity to make available more IP Address.

3.4: Hosts and Domains:

A host is any computer that is represented by an IP address, and the domains are a set of computers on a single network. There are two types of domains:

- IP domains: all computers that are defined under numeric IP.
- Name domains: a set of computers that are grouped under a single abbreviated name such as uk, com, edu, gov, etc.

3.5: Datagram Forwarding:

The connection service in the internet is basically through sending packets of data between computers through the internet. The size of the single IP datagram using the present scheme of TCP/IP reaches up to 64 Kb, but due to the devices that are used in the networks, such as modems and network cards, any individual host can send about 1.5 Kb. Each packet travels independently in the internet from one router to another until it reaches the recipient. In this way the packets are transmitted on the internet by routers, which are computers that connect networks together. (See Figure 7. Transmission of data).

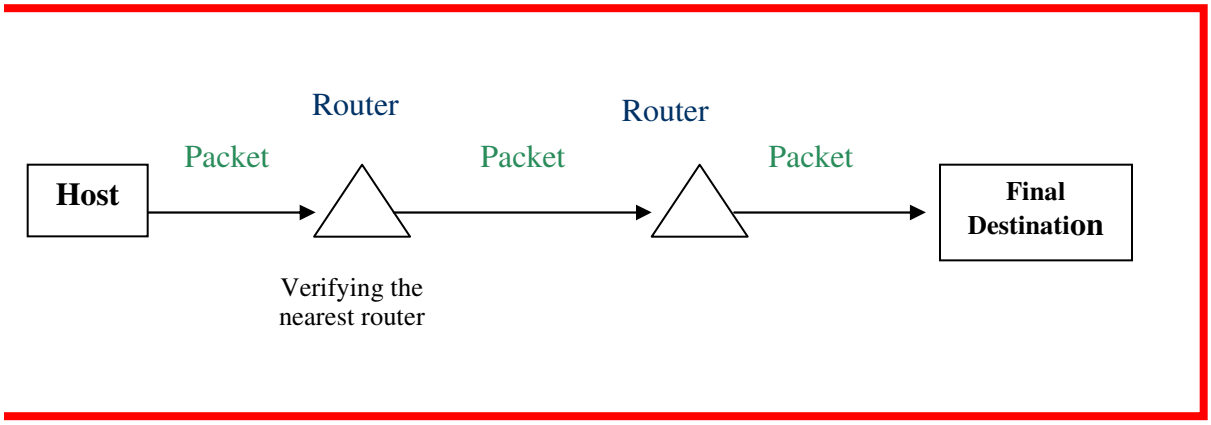

Figure 7. Transmission of Data

4.0: Conclusion:

It is taken for granted that the recent developments in communications have made the world a small village. Furthermore, the main challenge that the researchers and the developers always face is in trying to follow the recent technology and in trying to use this technology to develop communication. Yet, what is making it a hard task is the cost of development and upgrading. However, there are several

inventions in development, as has been seen in this report, which have appeared since the digital age began and with the revolution of the internet, which give tremendous impetus to the desire of mankind to develop communication.

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